Vibration Injury Network

Research Network on Detection and Prevention of Injuries due to Occupational Vibration Exposures

Normative vibrotactile thresholds measured at five European test centres

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Task: *To compare vibrotactile thresholds measured on healthy subjects between five European test centres so as to determine causes of variability in normative data and to provide population specific and method specific data for use by health professionals*

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Summary

Objectives: To compare vibrotactile thresholds measured on healthy subjects between five European test centres so as to determine causes of variability in normative data and to provide population specific and method specific data for use by health professionals.

Methods: Vibrotactile thresholds were measured on various fingers in 1008 subjects at 31.5 Hz to excite the Meissner's corpuscles (2531 measurements) and at 125 Hz to excite the Pacinian corpuscles (2807 measurements). There were 55 subjects at Centre 1, 465 subjects at Centre 2, 88 subjects at Centre 3, 24 subjects at Centre 4 and 376 subjects at Centre 5. Centres 1, 3, 4 and 5 used the up-and-down method of limits (von Békésy method) to obtain vibrotactile thresholds whilst Centre 2 used a stepping algorithm. Centres 1, 4 and 5 used an *HVLab* Tactile Vibrometer with a push force on the surround of 2 N, a probe contact force of 1 N and a probe diameter of 6 mm concentric to a 10 mm diameter hole in the surround. At these Centres, the rate of change of stimulus was 3dB/s and the measurement duration was 45 seconds. Centre 3 used a B & K shaker to provide the stimulation, no surround was used and the force on the 6 mm diameter contactor was unspecified. The measurement duration was determined by the time required for 6 reversals. At Centre 2, a 1.26 mm diameter contactor was mounted on a shaker connected to a modified manual audiometer to provide the stimulus with a 5 dB step size.

Results: Meissner's corpuscle specific thresholds (M thresholds) and Pacinian corpuscle specific thresholds (P thresholds) tended to be similar between centres using the same equipment and methods (Centres 1, 4 and 5). The M thresholds at Centre 2 were significantly higher than those at other centres, and M thresholds at Centre 3 were higher than those at Centres 1 and 4. The P thresholds at Centre 2 were significantly lower than those at other centres and P thresholds at Centre 3 were lower than those at Centre 1. Female subjects tended to exhibit lower M and P thresholds than male subjects. Any effects of occupation (white-collar compared to blue-collar) were found to be negligible in this study. Increasing age was found to increase both M and P thresholds, the effect being greater for the P thresholds than for the M thresholds. There were only few and inconsistent relationships between finger skin temperature and vibrotactile thresholds for the healthy subjects used in these studies. Both M thresholds and P thresholds were affected by measurement location. The tendency was for thresholds measured on the middle or index fingers to be lower than those measured on the little fingers, and for measurements made on the left hand to be lower than measurements made on the right hand. The effect of measurement location appeared to be greater for P thresholds than for M thresholds.

Conclusions: Vibrotactile thresholds are influenced by the measurement method but can be similar at different centres if similar methods are used. The thresholds are also dependent on the location of measurement, the age of the subject and the subject's gender. Normative data for various measurement locations on the hands for homogeneous groups of subjects are presented; these can be used to aide the diagnosis of peripheral neuropathy involving vibrotactile sensation.

Introduction

Measurements of vibrotactile thresholds on the fingers are currently used in several countries in Europe for assessing neurological dysfunction in workers exposed to hand-transmitted vibration (e.g. Bovenzi *et al*., 1997; Cock *et al*., 2000; Lindsell and Griffin, 1999; Lundström *et al*., 1999). Some workers have been found to suffer from diffuse neuropathies that become disabling (e.g. Brammer *et al*., 1987; Gemne, 1997;).

Various equipment and methods have been implemented for measuring vibrotactile thresholds. The different methods are unlikely to give similar thresholds due to differences in the applied stimulus, the skin-stimulus contact conditions and the methods of calculating thresholds (e.g. Maeda and Griffin 1994; Lindsell and Griffin, 1998).

This study was conducted to investigate the variability in vibrotactile thresholds between five European laboratories. In addition to differences between centres, factors that affect vibrotactile thresholds within centres (age, gender, measurement location, finger skin temperature) were also investigated.

Method

Vibrotactile threshold data were obtained from five laboratories, one in the United Kingdom (Centre 1), one in Belgium (Centre 2), one in Sweden (Centre 3), one in Italy (Centre 4) and one in France (Centre 5). All subjects for whom data were obtained were healthy and of working age. No subjects reported exposure to hand-transmitted vibration in the workplace. Subject characteristics that were obtained at each test centre are shown in Table 1. Measurement methods differed between locations. Table 2 shows the measurement parameters used at each centre.

Table 1, Table 2

All subjects gave their consent before measurements were made and each of the centres obtained approval for making the measurements from their local safety and ethics committees.

Analysis

Data were provided by centres as either r.m.s. accelerations (m/s^2) or decibels (dB with reference to 10^{-6} m/s^2). The r.m.s. accelerations have been transformed to decibels; when expressed as dB, normal Q-Q plots for the threshold data at each centre do not indicate substantial departures from normality.

Vibrotactile thresholds expressed as dBs have been described using the mean as the measure of central tendency and the standard deviation (SD) as the measure of spread.

One-way analysis of variance (ANOVA), Students t-tests for paired samples and Students t-tests for independent samples have been used to compare data within and between subjects. Pearson's correlation coefficients have been calculated to test for significant relations between variables. Curve estimation has been used to obtain best-fit linear models for co-varying data. Due to the complexity of the data and non-uniformity between test centres, it has not been possible to use generalised linear models to analyse the data. A probability of 5% has been chosen to indicate significance and 10% to indicate marginal significance in the analyses. When multiple comparisons have been performed, the significance level has been adjusted using the Bonferroni method. Data have been analysed using SPSS for Windows v7.5

Results

Age, finger skin temperature (FST) and vibrotactile thresholds for the Meissner's corpuscles (31.5 Hz or 32 Hz) are shown in Table 3. Table 4 gives the vibrotactile thresholds for the Pacinian corpuscles (125 Hz). Combined data, data for each centre and data for homogeneous sub-groups within centres are given. Mean (± 2 standard deviations) vibrotactile thresholds measured on each finger at each centre are illustrated in Figure 1 for the Meissner's corpuscle specific thresholds and Figure 2 for the Pacinian corpuscle specific thresholds.

Table 3, Table 4, Figure 1, Figure 2

Age and finger skin temperature (FST) were different between groups (ANOVA, $p < 0.001$). Independent samples t-tests were performed with the probability level adjusted for multiple comparisons. Subjects at Centre 5 were significantly older

than subjects at Centres 2, 3 and 4. Subjects at Centre 3 were significantly younger than subjects at other centres and subjects at Centre 4 were significantly younger than subjects at Centre 2. The FSTs were significantly higher at Centres 1 and 3 than at Centres 2, 4 and 5. The FSTs at Centre 5 were also significantly lower than the FSTs at Centre 4. Overall, FSTs were significantly negatively correlated with age; the older a subject the more likely he or she exhibited lower FSTs.

Differences between centres

One-way ANOVAs indicated significant differences between centres for both the Meissner's corpuscle specific thresholds and the Pacinian corpuscle specific thresholds.

For all Meissner's corpuscle specific thresholds combined, measurements were significantly different between centres, except between thresholds measured at Centre 1 and Centre 5. After correcting the significance level for multiple comparisons within fingers (i.e. for digit 2, digit 3 and digit 5 of each hand separately), thresholds did not differ between Centres 1, 4 and 5. Meissner's corpuscle specific thresholds at Centre 2 were significantly higher than those at other centres and Meissner corpuscle specific thresholds at Centre 3 were higher than those at Centres 1 and 4.

For all Pacinian corpuscle specific thresholds combined, measurements were significantly different between centres except for thresholds measured at Centre 1 which were only marginally lower than those measured at Centre 5. Within digits, Pacinian corpuscle specific thresholds measured on the left hand were not different between Centres 1, 4 and 5. Pacinian corpuscle specific thresholds measured on the right hand were higher at Centre 5 than at Centre 4 and Centre 1 but similar between Centres 1 and 4. Pacinian corpuscle specific thresholds measured at Centre 3 were similar to those measured at Centre 4, significantly higher than those measured at Centre 2 and significantly lower than those measured at Centre 1. Pacinian corpuscle specific thresholds measured at Centre 2 were significantly lower than those measured at other centres.

Effect of gender

Overall, both Meissner's corpuscle specific thresholds and Pacinian corpuscle specific thresholds were significantly different between males and females. Within digits, females had significantly lower Meissner's corpuscle specific thresholds on the right hand and digit 3 of the left hand than males. For Pacinian corpuscle specific thresholds, measurements on the right hand were significantly higher for females than for males but measurements were similar on the left hand between males and females.

Measurements were made on both male and female subjects at Centres 2, 4 and 5. For all measurements combined at Centre 2, females had significantly lower thresholds than males for both the Pacinian corpuscles and the Meissner's corpuscles. At Centre 5, females had significantly higher thresholds than the males. At Centre 4, there was not a significant difference between males and females for either the Meissner's corpuscle specific thresholds or the Pacinian corpuscle specific thresholds.

When considering Meissner's corpuscle specific threshold measurements at each centre and on each digit separately, and adjusting the significance level for multiple comparisons accordingly, there were no significant gender effects at Centre 4 or Centre 5. At Centre 2, females had lower Meissner's corpuscle specific thresholds on digit 5 of the right hand and digit 3 of the left hand than the males.

For Pacinian corpuscle specific thresholds, there were no gender effects observed at Centre 4. At Centre 2, females had significantly lower Pacinian corpuscle specific thresholds on all digits. At Centre 5, there were no significant differences between males and females for Pacinian corpuscle specific thresholds measured on the left hand. Measurements on the right hand were significantly higher for females than for males at this centre.

Effect of occupation

Overall, there was a significant difference between white-collar workers and blue-collar workers for both Meissner's corpuscle specific thresholds and Pacinian corpuscle specific thresholds. Centre 1 and Centre 2 made measurements on both white-collar workers and blue-collar workers. For measurements on all digits

combined within these two centres, there was a significant difference between white-collar and blue-collar workers only for Pacinian corpuscle specific thresholds measured at Centre 2. Within digits at Centre 2, there were no significant differences between white-collar workers and blue-collar workers.

Effect of measurement location

Due to the non-uniformity of measurement locations between centres and the significant differences observed between centres, the effect of measurement location has been considered within each centre separately.

At Centre 1, measurements were made on digit 3 and digit 5 of both hands on 36 subjects. For the Meissner's corpuscle specific thresholds, there were no differences between the various digits. For Pacinian corpuscle specific thresholds, measurements on digit 3 were significantly lower than measurements on digit 5 for both frequencies of measurement; there were no differences between hands. All measurements were significantly positively correlated between the four locations.

Measurements were made on digit 3 and digit 5 of both hands for 402 subjects and on digit 3 and digit 5 of the right hand for a further 30 subjects at Centre 2. The Meissner's corpuscle specific thresholds were significantly lower on digit 3 than digit 5 on the right hand. The Meissner's corpuscle specific thresholds were higher on digit 3 of the left hand than on digit 3 of the right hand but lower on digit 5 of the left hand than digit 5 of the right hand. For Pacinian corpuscle specific thresholds, measurements were lower on the left hand than the right hand and lower on digit 3 of each hand than on digit 5 of the same hand. All measurements were significantly positively correlated between measurement locations.

Centre 4 included measurements on digit 2, digit 3 and digit 5 of both hands for 24 subjects. For the Meissner's corpuscle specific thresholds, there were no significant differences between measurement locations. For the Pacinian corpuscle specific thresholds, measurements made on digits 2 and 3 of the left hand were significantly lower than measurements made on digit 5 of the left hand. A similar trend was observed for the right hand although this was not significant after correcting for multiple comparisons. Vibrotactile thresholds were all

positively correlated between the six measurement locations and 93% of the correlation coefficients achieved significance.

Measurements were made only on the dominant hand at Centre 5. All measurements on digit 3 were significantly lower than measurements on digit 5. All measurements were significantly positively correlated between locations.

Effect of age

Overall, both the Meissner's corpuscle specific thresholds and the Pacinian corpuscle specific thresholds were significantly positively correlated with age. Within Centres 2, 4 and 5, Meissner's corpuscle specific thresholds and Pacinian corpuscle specific thresholds were significantly positively correlated with age. At Centre 1, only the Pacinian corpuscle specific thresholds were significantly positively correlated with age and at Centre 3, neither threshold was correlated with age.

For the individual digits within Centre 1, 3 and 4, the Meissner's corpuscle specific thresholds were not significantly related to age. At Centres 2 and 5, the Meissner's corpuscle specific thresholds on each digit were significantly positively correlated with age. For the Pacinian corpuscle specific thresholds, measurements on individual digits were not related to age at Centres 1 and 2 but were significantly positively correlated with age at the other centres.

The positive correlation between age and thresholds tended to be observed when the data were split into groups of white-collar workers and blue-collar workers, or into groups of males and females. The Meissner's corpuscle specific thresholds were positively correlated with age on digits 2 and 3 of the right hand and digits 3 and 5 of the left hand for all blue-collar workers and on digits 3 and 5 of both hands for all white-collar workers. Males showed a significant positive correlation between Meissner's corpuscle specific thresholds on digits 3 and 5 of the left hand and females showed a significant positive correlation on digits 3 and 5 of both hands. For the Pacinian corpuscle specific thresholds, all measurements in white-collar workers were significantly positively correlated with age, as were Pacinian corpuscle specific thresholds measured on digit 3 of the right hand and digits 3 and 5 of the left hand in blue-collar workers. Males exhibited significant positive correlations between Pacinian corpuscle specific thresholds and age for all

measurements except those on digit 2 of the right hand and females showed significant positive correlations between Pacinian corpuscle specific thresholds and age for all measurements except for digit 2 on the left hand.

Best-fit linear models have been calculated for the effects of age on vibrotactile thresholds for each measurement location and for all measurement locations combined. The equations are given in Table 5.

Table 5

Effect of finger skin temperature

Overall, finger skin temperatures (FSTs) were not related to Pacinian corpuscle specific thresholds. There was a significant positive correlation between FSTs and Meissner's corpuscle specific thresholds. Within centres, only Meissner's corpuscle specific thresholds measured at Centres 1 and 2 were significantly related to FST; measurements at Centre 1 were negatively correlated with FSTs whilst measurements at Centre 2 were positively correlated with FSTs.

Within digits for all subjects, only Meissner's corpuscle specific thresholds on digit 2 of the right hand and Pacinian corpuscle specific thresholds on digit 3 and 5 of the left hand were significantly related to FST. After correcting the significance level for multiple comparisons, no homogeneous sub-groups exhibited significant relations between FSTs and thresholds for any of the measurement locations.

Conclusions

Vibrotactile thresholds can be similar at different centres if similar methods are used. However, the thresholds are influenced by the measurement method and different thresholds are obtained when methods differ. The thresholds are also dependent on the location of measurement, the age of the subject and the subject's gender.

Normative data for various measurement locations on the hands for homogeneous groups of subjects have been presented; these can be used to aid the diagnosis of peripheral neuropathy involving vibrotactile sensation.

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References

Bovenzi M, Apostoli P, Alessandro G, Vanoni O (1997) Changes over a workshift in aesthesiometric and vibrotactile perception thresholds of workers exposed to intermittent hand-transmitted vibration from impact wrenches. Occupational and Environmental Medicine, 54, 8, 577-587.

Brammer A J, Piercy, J E , Auger P L, Nohara S (1987) Tactile perception in hands occupationally exposed to vibration. The Journal of Hand Surgery, 12A, 5, 2, 870-875.

Cock N, Piette A, Malchaire J (2000) Can a battery of functional and sensory tests corroborate the sensorineural complaints of subjects working with vibrating tools? International Archives of Occupational and Environmental Health. 73, 5,:316-22.

Gemne G (1997) Diagnostics of hand-arm system disorders in workers who use vibrating tools. Occupational and Environmental Medicine, 54, 2, 90-95.

Lindsell C J, Griffin M J (1998) Standardised diagnostic methods for assessing components of the hand-arm vibration syndrome. HSE Books. CRR197/98, ISBN 0 7176 1640 1.

Lindsell C J, Griffin M J (1999) Thermal thresholds, vibrotactile thresholds and finger systolic blood pressures in dockyard workers exposed to hand transmitted vibration. International Archives of Occupational and Environmental Health 72, 6, 377-386.

Lundström R, Nilsson T, Burström L, Hagberg M (1999) Exposure-response relationship between hand-arm vibration and vibrotactile perception sensitivity. American Journal of Industrial Medicine. 35, 5, 456-64.

Maeda S, Griffin M J (1994) A comparison of vibrotactile thresholds on the finger obtained with different equipment. Ergonomics, 37, 8, 1391-1406.

Table 1 Characteristics of subjects at each of the five test centres

		Centre 1	Centre 2	Centre 3	Centre 4	Centre 5
		N = 55	N = 465	N = 88	N = 24	N = 376
Age	Years (Mean, SD)	34.8 (9.0)	35.9 (7.3)	26.9 (2.4)	31.2 (6.7)	38.1 (10.3)
Occupation	White-collar workers (N)	19	125	-	0	-
	Blue-collar workers (N)	36	340	-	24	-
Gender	Male (N)	55	373	88	10	219
	Female (N)	0	92	0	14	157
Preferred Hand	Left (N)	4	32	5	0	28
	Right (N)	50	433	82	24	335
	Ambidextrous (N)	1	0	1	0	13
Finger skin temperature*	°C (Mean, SD)	33.5 (2.5)	30.0 (3.6)†	34.2 (1.4)	30.7 (1.0)	29.8 (3.0)‡

† measured for 89 subjects only

‡ measured for 258 subjects only

* Finger skin temperature was measured on the index finger or middle finger of the right hand except at Centre 5 where finger skin temperature was measured on the middle finger of the dominant hand.

Table 2 Measurement methods used at the five test centres.

Parameter	Centre 1	Centre 2	Centre 3	Centre 4	Centre 5
Equipment	*HVLab* Tactile Vibrometer	Self built system	B & K	*HVLab* Tactile Vibrometer	*HVLab* Tactile Vibrometer
Measurement location	19 subjects, index finger, right hand 36 subjects, middle and little finger, both hands	33 subjects, index finger, right hand 402 subjects, middle and little finger, both hands 30 subjects, middle and little finger, right hand	Index finger, right hand	Index, middle and little finger, both hands	Middle and little finger, dominant hand
Contactor force	1 N	0.2 N	Unspecified	1 N	1 N
Push force on surround	2 N	No surround	No surround	2 N	2 N
Contactor diameter	6 mm	1.26 mm	6 mm	6 mm	6 mm
Diameter of hole in surround	10 mm	None	None	10 mm	10 mm
Psychophysical method	Up-and-down method of limits (von Békésy)	Stepping algorithm	Up-and-down method of limits (von Békésy	Up-and-down method of limits (von Békésy)	Up-and-down method of limits (von Békésy)
Rate of change of stimulus	3 dB/s	5 dB steps	?	3 dB/s	3 dB/s
Measurement duration	45 seconds	Long enough to cross threshold 3 times	Long enough for 6 reversals	45 seconds	45 seconds
Number of reversals	Minimum of 6		6	-	-
Threshold calculation	Mean of mean peak and mean trough (arithmetic)	?	?	Mean of mean peak and mean trough (arithmetic)	Mean of mean peak and mean trough (geometric)

Table 3 Age, finger skin temperatures and Meissner's corpuscle specific vibrotactile thresholds measured at 31.5 Hz for each subject grouping used in the analysis. The number of subjects in each group is given in Table 4.

Subject group	Age Years (Mean, SD)	FST °C (Mean, SD)	Vibrotactile threshold																			
			Left Hand									Right Hand								All		
			Digit 2			Digit 3			Digit 5			Digit 2			Digit 3			Digit 5				
			N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
All	35.8 (8.9)	31.0 (3.3)	24	102.4	5.9	450	111.3	7.1	421	112.0	6.8	164	109.8	6.2	737	108.7	8.3	735	109.7	8.4	2531	110.0	7.9
Centre 1	34.8 (9.0)	33.5 (2.5)				36	104.1	5.9	36	104.5	5.5	19	103.7	4.1	35	103.9	6.7	35	104.6	5.9	161	104.2	5.8
Centre 2	35.9 (7.3)	30.0 (3.6)				363	115.3	5.7	333	114.0	5.4	33	113.8	3.2	363	114.4	5.4	333	115.3	5.1	1425	114.2	5.4
Centre 3	26.9 (2.4)	34.2 (1.4)										88	112.0	4.6							88	112.0	4.6
Centre 4	31.2 (6.7)	30.7 (1.0)	24	102.4	5.9	24	102.8	5.8	24	103.5	5.8	24	101.0	2.8	24	102.7	4.7	24	101.7	5.0	144	102.4	5.1
Centre 5	38.1 (10.3)	29.7 (2.9)				27	101.4	4.7	28	105.2	8.2				315	103.3	7.1	343	105.3	8.0	713	104.3	7.6
Centre 1, male, white collar	29.1 (7.6)	32.9 (2.9)										19	103.7	4.1							19	103.7	4.1
Centre 1, male, blue collar	37.8 (8.3)	33.8 (2.2)				36	104.1	5.9	36	104.5	5.5				35	103.9	6.7	35	104.6	5.9	142	104.3	5.1
Centre 2, male, white collar	37.2 (7.0)	34.1 (1.4)				43	114.1	5.9	30	115.3	4.9	33	113.8	3.2	43	115.0	5.1	30	116.0	5.6	179	114.8	5.1
Centre 2, male, blue collar	35.4 (7.1)	28.8 (3.1)				228	113.9	5.6	228	114.0	5.4				228	114.5	5.2	228	115.9	4.7	912	114.6	5.3
Centre 2, female, white collar	40.2 (5.3)					49	111.0	5.9	32	113.6	4.3				49	114.1	5.6	32	114.2	4.8	162	113.1	5.5
Centre 2, female, blue collar	32.0 (8.0)					43	112.6	5.8	43	113.4	5.6				43	113.3	6.4	43	113.0	6.3	172	113.1	6.0
Centre 4, male, blue collar	30.1 (5.7)	30.9 (1.3)	10	101.6	6.2	10	102.8	6.9	10	104.0	6.8	10	101.0	3.6	10	101.9	3.7	10	102.2	4.3	60	102.2	5.3
Centre 4, female, blue collar	31.9 (7.5)	30.6 (0.9)	14	102.9	5.8	14	102.9	5.2	14	103.1	5.2	14	101.1	2.4	14	103.4	5.4	14	101.4	5.6	84	102.5	5.0
Centre 5, male	39.0 (10.2)	30.1 (2.7)				16	101.4	4.2	16	105.0	4.2				184	102.7	7.2	200	104.8	8.1	416	103.7	7.5
Centre 5, female	36.8 (10.5)	29.0 (3.1)				11	101.4	5.5	12	105.5	11.9				131	104.2	7.0	143	106.1	7.9	297	105.1	7.7

Table 4 Pacinian corpuscle specific vibrotactile thresholds measured at 125 Hz for each subject grouping used in the analysis. Age and finger skin temperature for the subject groups are given in Table 3.

Subject group		Vibrotactile threshold																			
		Left Hand									Right Hand								All		
		Digit 2			Digit 3			Digit 5			Digit 2			Digit 3			Digit 5				
	N	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
All	1008	24	106.7	6.0	519	101.0	8.1	489	102.6	8.4	164	104.0	6.2	806	105.9	10.0	805	108.5	10.9	2807	105.0	9.9
Centre 1	55				36	108.2	8.7	36	111.0	7.1	19	109.7	5.4	35	107.4	7.3	36	110.0	7.5	162	109.1	7.5
Centre 2	465				432	99.5	7.1	401	100.5	6.6	33	97.7	5.0	432	100.7	6.8	402	102.0	6.9	1700	100.6	6.9
Centre 3	88										88	104.3	5.1							88	104.3	5.1
Centre 4	24	24	106.7	6.0	24	107.3	5.7	24	109.4	5.8	24	107.2	4.5	24	107.1	5.6	24	109.0	5.6	144	107.8	5.6
Centre 5	376				27	110.0	10.4	28	115.9	12.1				315	112.7	10.1	343	115.8	10.6	713	114.2	10.6
Centre 1, male, white collar	19										19	109.7	5.4							19	109.7	5.4
Centre 1, male, blue collar	36				36	108.2	8.7	36	111.0	7.5				35	107.4	7.7	36	110.0	7.5	143	109.1	7.7
Centre 2, male, white collar	76				43	99.9	6.8	30	100.8	5.9	33	97.7	5.0	43	100.8	5.6	30	102.5	6.4	179	100.3	6.1
Centre 2, male, blue collar	297				297	100.1	6.9	296	101.2	6.4				297	101.1	6.7	297	102.6	6.7	1187	101.2	6.7
Centre 2, female, white collar	49				49	96.9	6.4	32	98.8	6.5				49	99.2	6.6	32	100.6	6.4	162	98.7	6.6
Centre 2, female, blue collar	43				43	97.7	8.4	43	97.2	7.8				43	98.8	8.5	43	99.1	8.0	172	98.2	8.1
Centre 4, male, blue collar	10	10	105.9	6.2	10	106.9	5.3	10	109.7	5.1	10	107.2	4.9	10	107.4	5.6	10	109.1	6.0	60	107.7	5.5
Centre 4, female, blue collar	14	14	107.3	6.0	14	107.6	6.2	14	109.2	6.4	14	107.2	4.4	14	106.9	5.8	14	108.9	5.5	84	107.9	5.6
Centre 5, male	219				16	110.3	8.7	16	116.2	10.0				184	111.3	9.7	200	114.6	10.2	416	113.0	10.1
Centre 5, female	157				11	109.7	12.9	12	115.4	14.9				131	114.8	10.3	143	117.5	11.0	297	116.0	11.0

Table 5 Best fit linear models describing the effect of age on vibrotactile thresholds. The parameters of the general equation for a straight line are given. The equation is x=m.a + c where x is the vibrotactile threshold, m is the coefficient of a, a is age and c is a constant.

Measurement			Constant	Coefficient
Meissner's corpuscle specific thresholds	All digits combined		106.899	0.0870**
	Right hand	Digit 2	109.825	-0.0012
		Digit 3	105.796	0.0798*
		Digit 5	107.578	0.0581+
	Left hand	Digit 2	93.421	0.2875
		Digit 3	105.288	0.1681**
		Digit 5	105.811	0.1748**
Pacinian corpuscle specific thresholds	All digits combined		93.417	0.3354**
	Right hand	Digit 2	104.110	-0.0034
		Digit 3	93.171	0.3438**
		Digit 5	94.020	0.3936**
	Left hand	Digit 2	95.571	0.3568+
		Digit 3	90.629	0.2884**
		Digit 5	92.551	0.2837**

+ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$

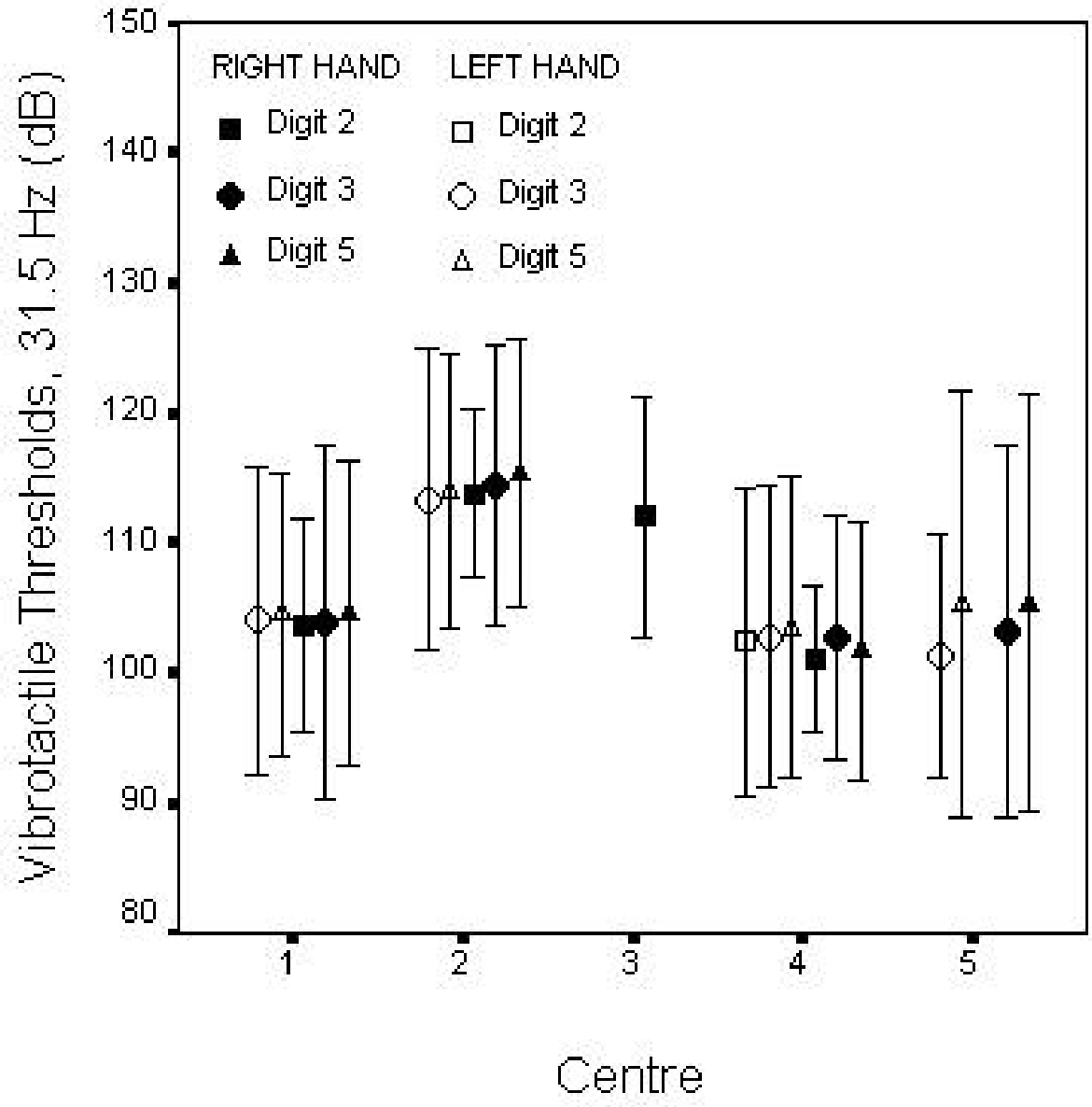

Figure 1 Mean (± 2 standard deviations) Meissner's corpuscle specific vibrotactile threshold measured at 5 centres.

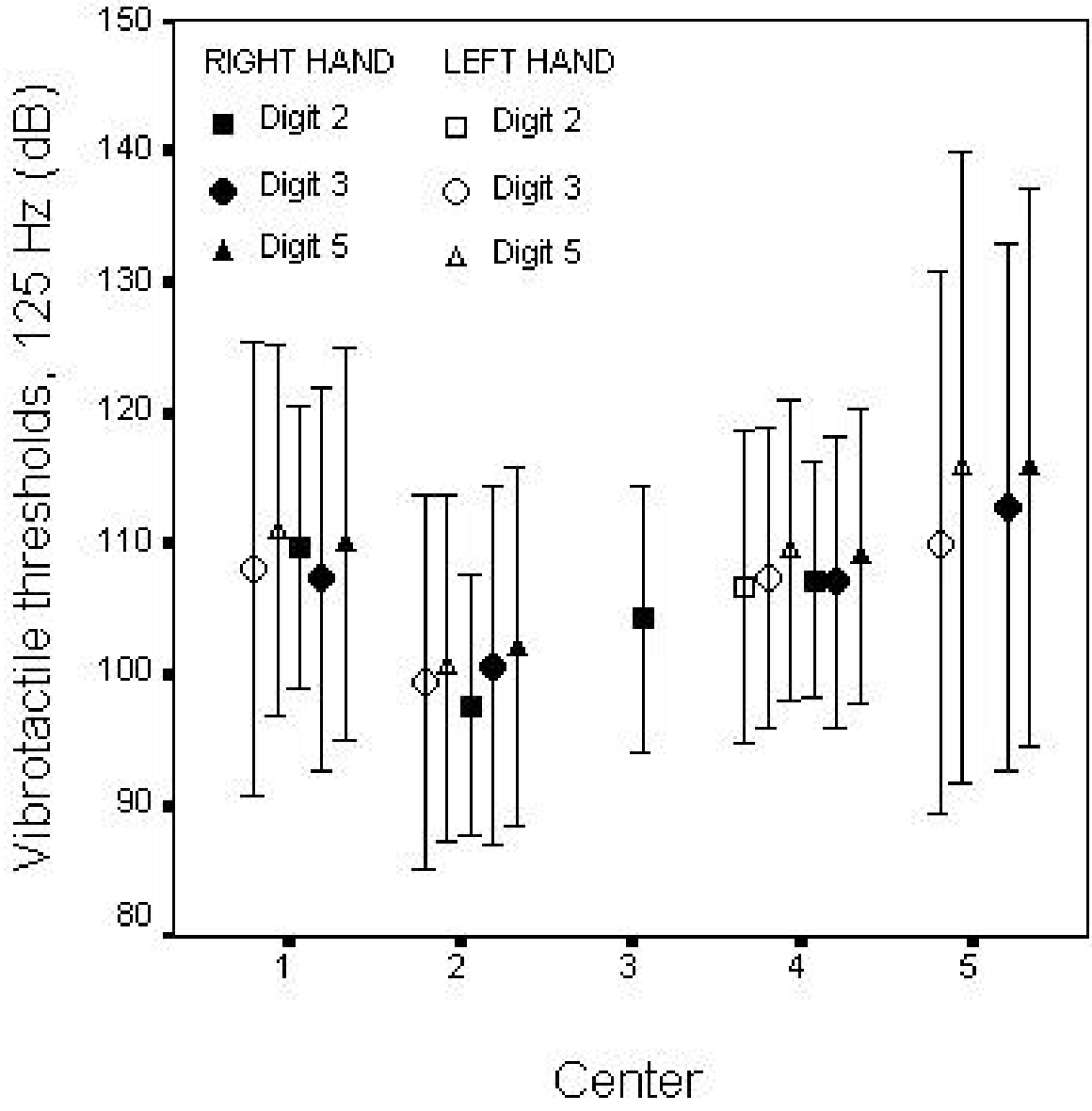

Figure 2 Mean (± 2 standard deviations) Pacinian corpuscle specific vibrotactile thresholds measured at 5 centres.